

Toward understanding relativistic heavy-ion collisions with the STAR detector at RHIC

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We have pursued the following physics analyses: I) bottomonium (Upsilon) production via Upsilon+hadron correlations, II) long-range pseudorapidity correlations in heavy-ion collisions via high- $p_T \pi^0$ and direct γ triggers, and III) the energy loss mechanism in heavy-ion collisions via the azimuthal anisotropy of high- $p_T \pi^0$ and direct photons. Finally, we have been involved in simulations for a STAR upgrade project, the Muon Telescope Detector.

I. Upsilon + Hadron Correlations:

We have performed the Upsilon+hadron correlation analysis on the Run-9 p+p data set, as well as the Run-8 d+Au data set. Figure 1 (left) shows the reconstructed mass from e^+e^- pairs (black) and like-sign pairs (red) from our Run-9 analysis. Figure 1 (right) shows the background-subtracted mass distribution.

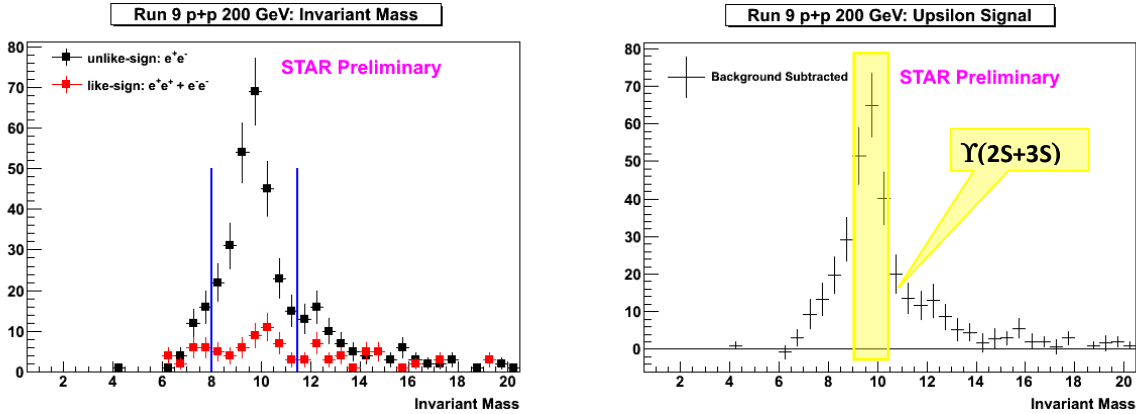


FIG. 1. (Left) Invariant mass distribution of e^+e^- pairs (black) and like-sign pairs (red) calculated in p+p events. (Right) Background-subtracted mass distribution.

The high signal to background ratio enables us to perform an analysis of Upsilon + Hadron correlations. Possible insight into the prompt production mechanism of heavy quarkonium can be obtained from hadronic activity measured near the Upsilon. Figure 2 shows our results for the azimuthal correlation between hadrons and the Upsilon in (left) d+Au events and (right) p+p events.

These plots are not yet corrected for the efficiencies of the associated hadrons. We have spent quite some time developing the cuts on associated hadrons to best reject pile-up tracks. We have calculated the efficiencies for our track cuts using pions embedded in d+Au events, and recently have also done the same for pions embedded in p+p events. This allows us to apply the final efficiency corrections.

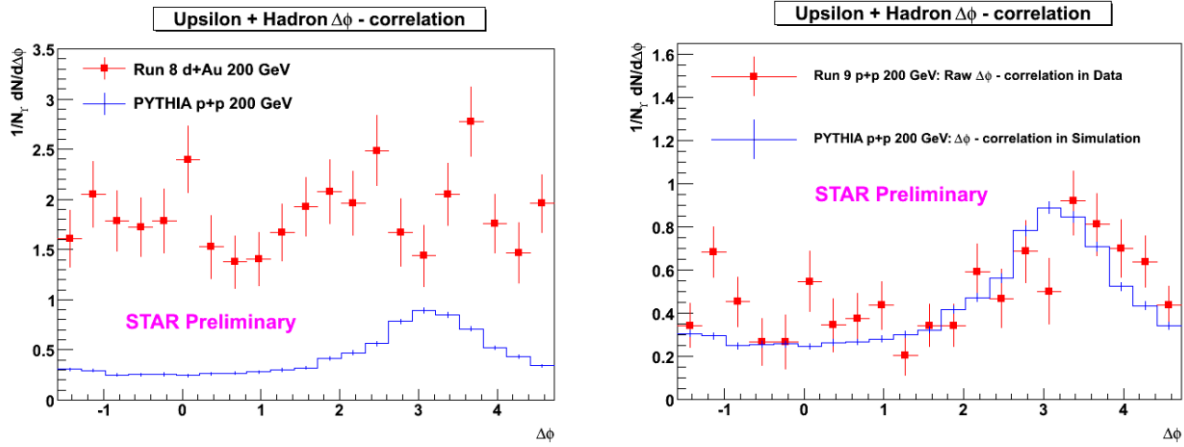


FIG. 2. Raw $\Delta\phi$ -correlation of hadrons with respect to the Upsilon in (left) d+Au events and (right) p+p events.

II. The “ridge” via high- p_T γ/π^0 triggers:

The “ridge” has been observed as a long-range correlation in $\Delta\eta$ with respect to a high p_T trigger. It has previously only been measured in correlations with charged hadron triggers. This previous measurement has large uncertainties (including large statistical errors for $p_T > 5$ GeV/c) making it difficult to conclude whether the ridge persists up to trigger p_T exceeding 5 GeV/c. We are extending the measurement of the ridge to higher p_T using photon triggers. Figure 3 shows the ridge yield in central Au+Au events, extracted by two different methods shown in the left and right plots, as a function of trigger p_T . The results are shown for inclusive photon triggers, π^0 triggers, and triggers rich in direct photons. The direct γ/π^0 discrimination is performed using the transverse shower profile measured with

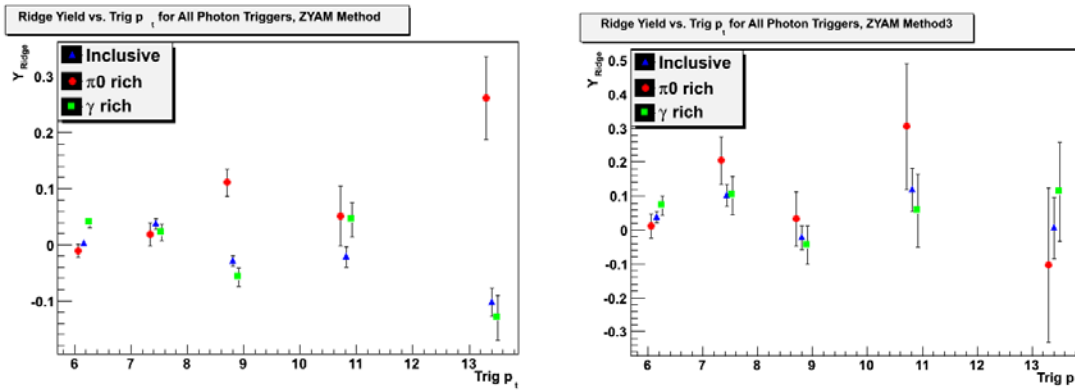


FIG. 3. The “ridge” yields measured in central Au+Au collisions (Run 7), extracted with 2 different methods shown left and right, as a function of trigger p_T for inclusive photon triggers, π^0 triggers, and direct-photon-rich triggers.

the Barrel Shower Maximum Detector (BSMD). The results seem to indicate that there is no significant ridge yield at these high trigger p_T values, but with large statistical errors. We are currently working on finalizing the systematic errors for these measurements. We are also exploring the possibility of improving the statistical significance using Run-10 Au+Au data.

III. Photon v_2 Measurement:

One of the puzzling conclusions that came from our γ -jet measurement is that there does not seem to be significant path-length dependence to parton energy loss. However, hadrons at high p_T have been measured to have a positive anisotropy (v_2) with respect to the reaction plane, which was explained as being due to larger energy loss for partons traveling through the long part of the reaction zone (out of the reaction plane) than the short path (in the reaction plane). How much of this measured anisotropy is due to a bias of the reaction plane determination, arising from the presence of jets, is also not fully understood yet. We have recently been working on a photon v_2 measurement. Direct photons do not lose energy, and thus should not have a positive v_2 . Neutral clusters from a high- p_T π^0 can be selected using the transverse shower profile measured in the BSMD, and a direct photon v_2 measurement can be extracted. Figure 4 shows the v_2 measurement for charged hadrons (for $p_T < 8$ GeV/c) and for inclusive photons, π^0 , and direct photons (for $p_T > 8$ GeV/c).

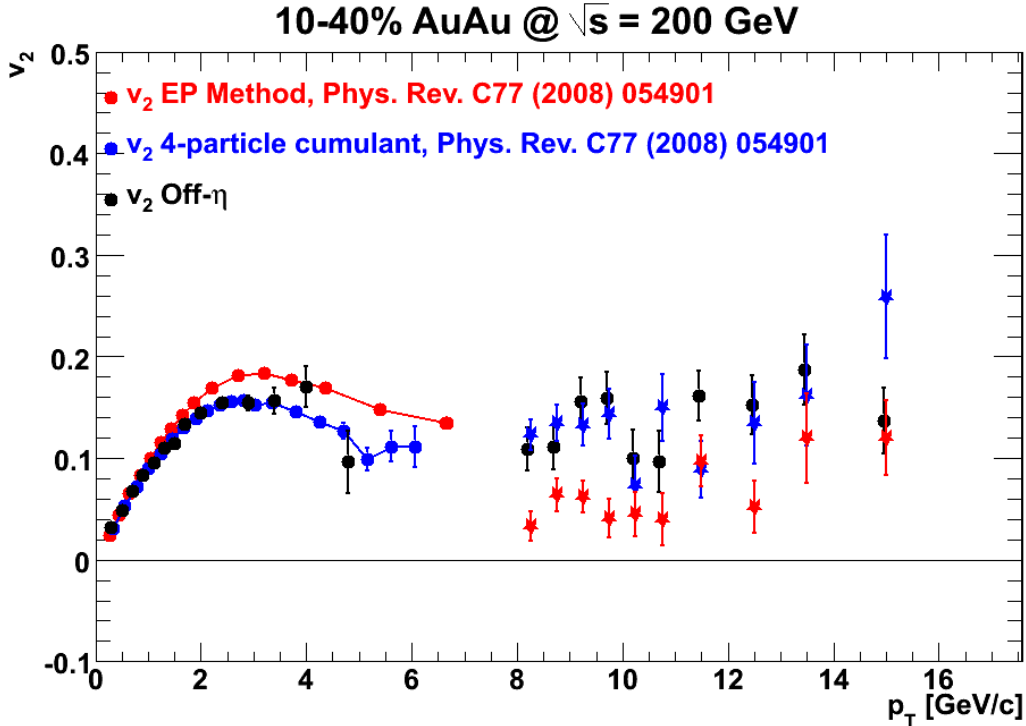


FIG. 4. Azimuthal anisotropy of inclusive photons, π^0 , γ_{direct} , and charged particles as a function of p_T .

Although the direct photon v_2 is smaller than that for π^0 , it is not zero. This may indicate that even when the reaction plane is determined using low- p_T particles with opposite-sign pseudorapidity relative to the particles measured with respect to the reaction plane (“off- η ”), there is a bias in the reaction-plane determination due to the presence of jets. We are currently working on finalizing these results for publication.

IV. Simulations for the Muon Telescope Detector

We have been working on simulations exploring the physics goals that can be attained with the STAR upgrade project of the Muon Telescope Detector (MTD). One of these physics goals is to separate J/Ψ originating from B decays from primordial J/Ψ , using the MTD to identify muons and the Heavy Flavor Tracker to measure the decay length. Figure 5 shows the reconstructed invariant mass of simulated particles that were embedded into real events. The following particles were embedded in each event.

- $B^+ \rightarrow J/\psi + K^+ \rightarrow \mu^+ + \mu^- + K^+$
- $J/\psi \rightarrow \mu^+ + \mu^-$
- $\eta \rightarrow \mu^+ + \mu^- + \gamma$
- $\Sigma^+ \rightarrow \mu^+ + \mu^- + p$

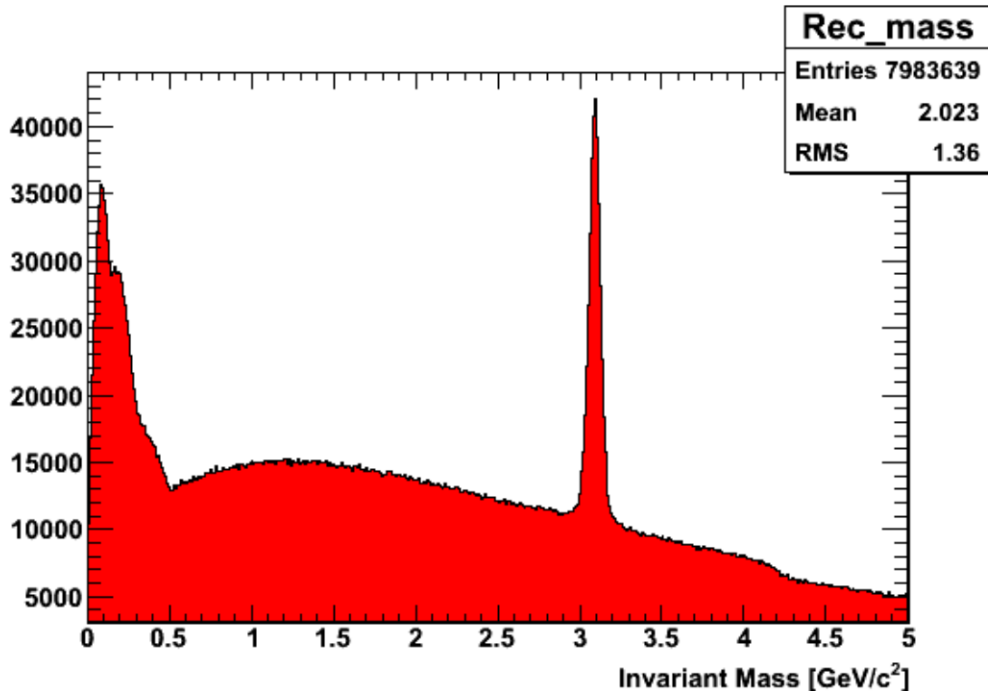


FIG. 5. Reconstructed invariant mass for all pairs of reconstructed tracks from simulation (without cuts on particle ID).

We are currently calculating the decay length of the J/ψ from the primary vertex in order to separate B decays from primordial J/ψ .